Chapter 3
Historical Data: Influence on Pumping/Injection and Drawdown Results

3-1. General

a. Purpose. The primary purpose of routine maintenance monitoring data acquisition is to provide information to chart trends in historical well and system performance. These changes over time indicate performance change, and trends are used to schedule maintenance activities. A checklist is provided in Chapter 8 for use in assessing the adequacy of well maintenance actions.

b. Key factors. The key factors in maintenance monitoring analyses are not the absolute numerical values (e.g., total Fe = 2.6), but the changes over time (total Fe was 2.6, 6 months later it was 0.6). A significant change in parameters indicates that the well may be in need of attention**,** or indicates biogeochemical changes of interest as microorganisms extract Fe, PO_4, etc., which may eventually lead to well performance changes. In any system or activity, data may be collected to fulfill some past directive, but the purpose for the activity may be lost over time as personnel change. Personnel involved in well maintenance should be conversant with all of the following sections.

3-2. Pumping Rates

The typical pumps used on HTRW projects are the widespread centrifugal pump designs adapted for well applications. In centrifugal pumps, output flow is in a dynamic relationship with system head: as system head is raised and lowered (e.g., due to clogging or other system hydraulic fluctuations), flow lowers or rises in inverse proportion. Changes in pumping rates over time will result due to changes in pumping head.

a. Internal pump changes. Clogging (increased resistance) and wear (reduced pressure) both result in lowered pump output, usually as a gradual declining trend. In submersible or lineshaft turbine well pumps, an abrupt loss of output usually is due to a hole developing in discharge piping. Another cause may be an inadvertent valve closing or other obstruction.

b. External head changes. If regional or pumping/injection head changes, this change will affect the pump output of an otherwise properly functioning pump. While direct measurement of water level (Section 3-4) is a more sensitive parameter, increased drawdown may be reflected in reduced flow. The size of this effect is specific to the pump.

c. System demand changes. Operational changes may affect the flow and efficiency of a pump. Restricting flow (e.g., for plume management) may be reflected in a pump operating inefficiently and having a shortened operating life.

3-3. Wellhead Pressure

Wellhead (system) pressure in the pump discharge significantly affects pump output flow (Section 3-2) and likewise affects injection acceptance. If system head increases, a centrifugal pump cannot produce as much output. Reduced flow then also may be a reflection of increased system head. This in turn is most typically a result of clogging activity. However, other causes, such as inadvertent valve closing or insufficient power, should also be investigated.

3-4. Water-Level Data

a. General use of water-level data. Water-level data, combined with flow data, can be used to chart changes in well specific capacity (and aquifer and well loss) over time. The longer and more representative the water-level history, the more reliable the trends that can be drawn from the data.

b. Internal pumping/recharge well levels. Except when static, these levels only reliably reflect the dynamics inside the well itself. Pumping output flow divided by the pumping (or injection) dynamic level provides specific capacity (Section 2-2). This calculation should also be made over time. As with the source data, the longer and more representative (seasonal, site pumping pattern) the specific capacity history, the more likely that valid trends can be drawn.

c. Comparisons of water levels. Pumping/injection water levels in wells typically differ (sometimes dramatically) from levels outside the casing. For direct comparison with aquifer loss and well loss calculations (Section 2-2) and routine monitoring, these differences can be used to narrow down

- Whether a change in pumping water level reflects a "regional" (site) trend.
- Where clogs are occurring.

(1) Pumping or injection dynamic level to filter pack piezometer comparisons are used to determine whether or not clogging is in the screen and filter pack. Installation of in-screen and satellite rehabilitation wells facilitates this monitoring (Section 5.4 and Alford and Cullimore 1999).

(2) Pumping or injection dynamic level to area monitoring well comparisons are used to determine if clogging is occurring in the screen and filter pack vicinity, or whether a change in pumping water reflects change at the "regional" scale.

(3) Unit-specific piezometer levels are used to determine what changes are occurring in the contributions by multiple units to a well.

3-5. Piezometric Data

Piezometric data provide water levels outside the immediate casing and pumping influence of a well. Piezometers (water-level monitoring wells) offer information on the response of a producing or accepting unit to change induced by site activities in addition to larger scale effects (e.g., changes in water table). As with pumping and recharge wells, the reliability of water-level response in monitoring wells depends on the wells' original design, development, and maintenance. A Standard Guide to procedures for this purpose has been published by ASTM (D 5978).

3-6. Electrical (Power) Data

Power component (V, A, ϕ) data (Section 2-7) charted over time provide a history of motor and power system changes. Historically, power problems may be the most common source of well problems. Power supply consistency is sometimes suspect, especially with ϕ imbalance. A history of ϕ imbalance data can provide the evidence needed to take well system power source problems to the power supply for correction.

a. Off-grid power quality. On generator- or solar-run systems, V and A changes reflect variability of the quality of power supplied and can provide ideas on what changes may be necessary.

b. Use of power data. Within a pump circuit, changes in amperage draw can be used to spot worn motors, or pumping system problems such as a clogged or perforated discharge line. As with the hydrologic data, the longer and more complete the records, the more likely that valid trends can be charted.

3-7. Video for Historical Comparison

When properly used, downhole video provides a direct view of conditions within wells. Video documents the as-built condition and timing of subsequent well damage and deterioration. Types of clogging conditions can be identified visually with some background. A progression of videos in any particular well, especially from the original construction condition, provides a direct way to watch changing conditions in the well (e.g., progressing screen corrosion or biofouling development). A video can also be used for comparison to file records where file records are suspect or incomplete.

3-8. Piezometric Maps

Existing interpretation aids available on typical HTRW projects can be used to assist in performance analysis. Piezometric or water table maps provide information on "regional" head data that influence specific capacity, and help to illustrate anomalies around pumping wells. Depths of water-bearing formation exposure and evidence of pumping centers can also provide insight into well-clogging oxidation occurrence in a well field.

3-9. Geologic Regime

a. Information on geologic maps. Geologic maps and cross-sections provide information on the influence of stratification and particle and geochemical types on well performance and degradation, and how effective original well designs were. Trouble-causing situations such as long, large-particle-size filter packs in variable stratified aquifers can be identified. Expected well treatment problems such as overdeveloping clay lenses can be predicted. Good geology and geophysical data relevant to the well's location are essential for proper well design.

b. Problems with too little geologic information. Well systems are often designed based on too little geologic site information. Problems that crop up often have a basis in a well being designed for a generic site condition, sometimes based on single borings, instead of well-site specific data. Files reveal when this is the case when multiple wells on a site will have identical depths, screen slot sizes, and filter packs. Results include screens and filter packs that are too fine or too coarse for the formation material and generally poor hydraulic efficiency.

c. Preserving original information. Because interpretations of geologic data over time may be distorted or simplified, it is recommended that original field notes be preserved for reference. Good data collection and analysis save operational money in the long term by aiding good well design that improves the capability of facility operators to maintain well systems. It is important that facilities maintain an archive that remains available and accessible despite management changes for use by future technical oversight or advising personnel (Section 4-3).

3-10. Maintenance Logs for Individual Wells

a. File elements. Section 2-10 reviews major file elements for well system maintenance. While general site information such as piezometric maps can be held centrally, files should be kept for individual wells to record their specific O&M histories.

b. Information recorded at well site. As an onsite backup, brief basic information on the well should be kept within the casing or casing protection sleeve or structure. This information should include:

- Dimensions of the entire well (depth), casing (length) and screen (length, location, type, and slot sizes), and filter pack (length, thickness, and particle sieve sizes).
- Material construction of each.
- Pump and power information.
- Information on any inserts downhole.
- Last service date and information on how to obtain more detailed records.

c. Offsite backup information. Files and video tapes kept at the project site should be duplicated at an offsite location that will continue to be available to site O&M personnel perpetually, regardless of changes in project management or service provider firms.

3-11. Downtime History

a. Information from well files. Well files should include a brief comment section on history of the total (project site) system for use in pinpointing causes and effects. Service intervals, costs, details of persons and companies involved, and analyses of results (what works, what doesn't, specific capacity changes) should be included for a history analysis, and for the sake of the next person (perhaps years in the future and unacquainted with the last service action).

b. Out-of-operation information. It is sometimes most useful to know why and how long a well was out of operation. For example:

(1) It is commonly the case on HTRW remediation sites to construct wells and then to leave them sitting idle for long periods during project development. It is widely observed that this practice results in wells that must be rehabilitated before they can be used (Borch, Smith, and Noble 1993; Smith 1995; NGWA 1998).

(2) Sites and individual wells may experience periods of hiatus in operations for various reasons. Again, equipped, developed wells, perhaps already with developing degrading conditions, sit idle.

(3) Such information can help personnel in troubleshooting problems down the line to make sense of the condition they find. Checklists for site well array O&M planning are provided in Chapter 8.